*Route No. 2 Roebling-Burlington*

August 1922

# Road Builders' Supplement

Vol. II No. 1

*"Center Joint" type of construction, showing re-inforcing fabric in place (in foreground); and placing concrete over fabric. (Budd Lake, Route 5)*

## Note

The papers presented at the recent Convention of the New Jersey Highway Association, and the discussions following them, are such a valuable contribution to the progress of road-building that it has been decided to publish them in full with as many as possible of the charts and illustrations used. (It has not been possible to include all of these, however, so there are occasional references in the text, to photographs and charts which have not been reproduced).

Our aim is to publish one or two of the Convention papers, with the discussion thereon, each month. We suggest that these be carefully filed, so that the reader may keep the complete set, which will make a very valuable addition to his road-building library.

This month we are printing "Merits of Bar Reinforcement for Concrete Pavements", by W. S. Edge, Concrete Steel Company, and the discussion thereon at the convention; also "The Proper Weight and Methods to Use to Secure the Desired Results with Sheet Fabric Reinforcement for Concrete Pavements", by W. C. Kuhn, American Steel and Wire Co., and the discussion thereon at the convention, and "Contract News" prepared to August 7, 1922.

Next month there will be published "The Proper Treatment of Posts for Guard Rails", by Edward T. Paddock, Carbolineum Wood Preserving Company, and the discussion thereon at the convention; also "The Advantages and Objections of a Sheet Asphalt Pavement With and Without a Binder Course", by Abram Swan, City Engineer, Trenton, New Jersey, and the discussion thereon at the convention.

# The Proper Weight and Methods to Use to Secure the Desired Results with Sheet Fabric Reinforcement for Concrete Pavements

**By Mr. W. C. Kuhn, American Steel and Wire Co.**

This is a subject far reaching in its possiblities and on which there has been considerable thought and investigation, by engineers and others interested in highway construction.

We all must admit at the start, that there is still a lot to be learned about the construction of highways, and judging from the various specifications for steel reinforcement for cement concrete pavements, we are far from the ideal to which we are all striving. Each year's work, however, is adding to our fund of knowledge, and it is quite possible, the time is not far distant, when we will have standard specifications for reinforced cement concrete pavements.

As my subject has two subdivisions I will take up first—The Proper Weight of Steel Fabric Reinforcement for Concrete Pavements.

On this question, at the present time, there is a wide variation as to specifications, running from 25 pounds per 100 sq. ft. to 90 pounds per 100 sq. ft. In New York State alone, there were five different weights, i. e.—25, 30, 40, 56 and 60 pounds per 100 sq. ft., the weight called for depending on the conditions to be met on each project. New York this year adopted 63 pounds per 100 sq. ft. as standard.

Pennsylvania State specifications for the past two years have called for 56 pounds per 100 sq. ft., an increase over their previous specifications which called for 25 pounds per 100 sq. ft. This State is now considering the advisability of increasing the 56 pound specification, and at this writing have above decided on 65 pounds as standard.

Throughout the New England States the specifications have varied from 25 pounds to 40 pounds per 100 sq. ft., one contract in Bennington, Vt., calling for two lines of reinforcement 28 and 40 pounds respectively, making a total of 68 pounds per 100 sq. ft.

In the South 25 pounds per 100 sq. ft. was the usual specification for the few reinforced concrete highways that were built up to the past year. However, on work advertised during the Fall of 1920 and subsequently, the engineers in Virginia, West Virginia and North Carolina have been specifying for heavier reinforcement, but South Carolina still calls for 25 pounds per 100 sq. ft.

In the middle West the specifications vary from 30 pounds to 55 pounds per 100 sq. ft., Kansas specifying 45 pounds, Kentucky 40 pounds, Minnesota 50 to 55 pounds, Ohio 30 pounds and Arkansas 40 pounds.

In your own State of New Jersey 34, 45 and 56 pounds per 100 sq. ft. have been specified for single line reinforcement, and on double line reinforcement 34 and 56 pounds, making a total of 90 pounds. The 34 pound specifications have been chiefly for county work, and there are many reinforced concrete roads in New Jersey with 34 pounds of steel that are standing up perfectly. A number of these are located near Freehold.

The 45 pound specification was for the two sections of the Fort Lee Turnpike, across the North Jersey meadows. This heavier fabric was specified to offset the hazards of the soft ground over which the road was constructed. The results seem to have justified the extra steel as one section 3500 ft. long has been down since 1917 and the second section, 1000 ft. long since 1919, and there are only one or two cracks in the entire road. There is a tendency, however, to increase the New Jersey County specifications to 56 pounds per 100 sq. ft. to correspond to the State specifications for single line reinforcement. Judging from the results that have been obtained by the use of 34 pound material, I do not see the logic of increasing the cost of the road to this extent, especially in view of the fact that practically all county roads are in the secondary system and not subject to the heavy traffic of the main or through routes. On main lines where the thickness of the slab has been increased to 8½ or 10 inches or more, I consider the 56 pound specifications more justified.

The manufacturer of steel has no objections, from a sales standpoint, to the increase in weight, as this means more tonnage; but there is certainly a limit beyond which it would not be justifiable to go, based on adequate strength and economy.

The primary reason for reinforcing cement concrete pavements is to take care of contraction and expansion due to temperature changes. Steel having practically the same co-efficient of expansion as concrete, it permits the entire mass to contract or expand uniformly. Steel also adds tensile strength to the concrete. This is a decided advantage during such times as the concrete is contracting. The friction between the slab and the sub-grade is apt to be sufficient to cause the unreinforced slab to crack due to the low tensile strength of the concrete. With the reinforcement in the slab this cracking is prevented.

Steel reinforcement also adds strength to the slab and helps to distribute the stress caused by any deficiency in the sustaining power of the subgrade. It also binds the concrete together and prevents cracking when the slab is forced upward by the action of frost. If by any chance the concrete should crack, the steel reinforcement holds the slab together and prevents the cracks spreading, thereby preventing any appreciable amount of moisture reaching the subgrade. This is borne out by the experience of the City of Sheboygan, Wisc. This City put down their first reinforced concrete pavement on North 6th St. in August 1911. It was a two course pavement reinforced with Triangle Mesh style No. 7 having No. 12 gage longitudinal and No. 14 gage cross wires all 4 inches center to center and weighing 21 lbs. per 100 sq. ft. Mr. C. N. Boley, City Engineer, advises that while small cracks formed, these were not maintained in any way until the year 1919. In November 1921 the pavement was torn up to put in sewers and upon inspecting the pieces of concrete removed it was found that the wires showed no signs of deterioration and measured full gage. This is another instance proving that steel properly imbedded in concrete does not rust and functions perfectly regardless of the length of time the concrete has been in place. This information was furnished by Mr. Boley in his letter December 9th, 1921, to the American Steel & Wire Company at Chicago. Wide cracks permit water to reach the subgrade and thoroughly saturate it, with the result that further freezing causes greater damage. The fact that steel reinforcement adds strength to the concrete road seems to be confirmed by the comparison of roads now in service. An instance is the section of Bergen Turnpike, not reinforced, which is rapidly breaking up, and the Fort Lee Turnpike, previously mentioned, which is reinforced and was constructed under practically the same conditions as to subgrade, materials, etc., and has developed only one or two cracks.

As our highway traffic is increasing daily and the weights of loaded trucks seem to be almost unlimited, it has been necessary to endeavor to provide roads that will be capable of meeting future requirements in so far as we are able to foresee them. For this reason the thickness of the concrete slab has been increased from 6 and 7 inches to as much as 10 and 12 inches at the crown with a corresponding increase at the sides. Naturally this would require a greater amount of steel to reinforce the greater volume of concrete.

Therefore, considering the manner in which the thinner slabs have stood up reinforced with 25 to 35 lbs. per 100 sq. ft., it is my opinion that 50 lbs. per 100 sq. ft. or say 56 lbs. as in New Jersey's 1921 specifications, is ample reinforcement for satisfactory results.

It is not practicable to design and construct our concrete highways as a clear span from edge to edge of the slab. This would make the cost of construction so expensive that it would be prohibitive. It is, therefore, necessary to properly prepare the subgrade by draining and rolling, so that there is reasonable assurance of the slab being supported at all points. We, therefore, get back to

*Showing Wire Fabric Reinforcing in Place (Budd Lake) Route 5*

the original intention of reinforcing for contraction and expansion, and any steel added over and above this can be considered as an extra expense.

This brings us to the second part of my subject, i. e. the proper Methods to Use to Secure the Desired Results with Sheet Fabric Reinforcement for Concrete Pavements.

Under this heading can be included the type of fabric and its location in the slab.

Sheet fabric would include any type of woven wire reinforcement, or expanded metal.

All members both longitudinal and transverse should be uniformly spaced and securely fastened together at each intersection. This insures having the required area and weight uniform throughout the slab and provides for full benefit from the reinforcement and maximum life for the road. The area of steel per foot in each direction should be specified, as well as the minimum and maximum spacing for all members composing the fabric.

As it is a fact that Cold Drawn Wire has a higher tensile strength than rolled bars, this should be taken into consideration and an increase in weight and area should be required when bars are substituted. Otherwise, a certain amount of strength would be lost which is most undesirable. Along this line I might mention a report of a test made by the Pittsburg Testing Laboratory, Pittsburg, Pa. Laboratory No. 47238, made August 18th, 1920, for the National Steel Fabric Company, in which it is shown that a 3/8 inch dia. round bar with an area of .1093 sq. in., a circumference of 1.171 in. and a strength of 66,693 pounds per sq. in. does not possess the advantages of 5 No. 8 wires having a total area of .1005 sq. in., a total circumference of 2.515 in. and a strength of 83,490 pounds per sq. in.; further a 1/2 inch diameter round bar with an area of .1982 sq. in., a circumference of 1.577 and a strength of 69,063 pounds per sq. in. as compared with 8 No. 7 wires having a total area of .1944 sq. in. a total circumference of 4.427 inches and a strength of 81,237 pounds per sq. in. From this it will be seen that the wire has a bonding surface of two to three times the bars and a tensile strength 30% higher, with the additional advantage of having the steel better distributed throughout the slab.

My suggestion for the specifications would be as follows:

## SPECIFICATIONS FABRIC REINFORCEMENT FOR CONCRETE ROADS AND PAVEMENT

The reinforcement used shall be a fabric of cold drawn steel wire, the members of which shall develop an ultimate tensile strength of not less than 70,000 lbs. per square inch and shall be capable of bending cold 180 degrees around one diameter without fracture. The fabric shall be free from excessive rust, scale or coating of any character which will impair the bond with the concrete.

The main wires of the fabric shall be spaced not less than four inches (4 in.) or more than six inches (6 in.) apart and shall have a sectional area of not less than .140 square inches of steel per foot of fabric. The transverse wires of the fabric shall be spaced not more than twelve (12 in.) apart and shall have a sectional area of not less than .025 square inches of steel per foot of fabric.

The above type of fabric will weigh 56 lbs. per 100 sq. ft.

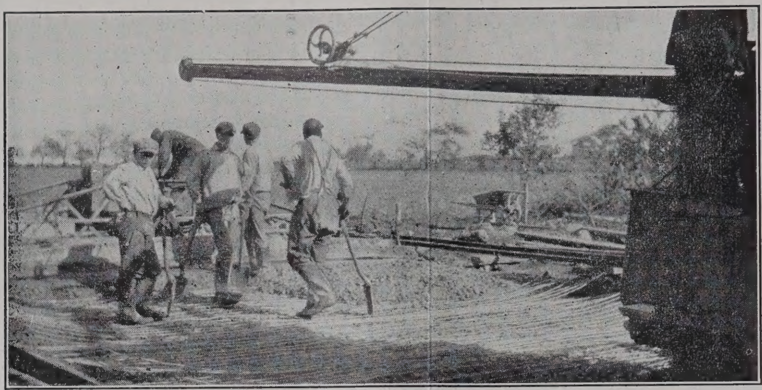
The fabric should be placed in the road 2 inches from the top of the finished slab. This allows the reinforcement to act in tension when it is most needed, which is at the time the slab is settling after a thaw. My contention is that when the subgrade freezes the heaving action will be fairly uniform across the slab. When the thaw occurs, it is the outer edges of the slab that are apt to be first affected, allowing a more rapid settlement at these points than at the center of the road. This would tend to cause a canti-lever effect throwing the top of the slab in tension, and the steel being located near the top would add strength to the concrete and prevent cracking.

Over sections of the country where the subgrade is poor, I believe two lines of reinforcement are advisable, and the heavier fabric should be not less than 2 inches from the bottom of the slab. With two lines of steel the slab is reinforced for both the heaving action of frost, and the bending action of loading.

Experience has shown that the cracks that cause the most trouble are those running approximately parallel with and along the center line of the road; therefore, the greater portion of the reinforcement should be placed across the pavement. I consider this holds for the road constructed with the center longitudinal crack as well as the single slab construction.

The "Desired Results" in road construction are maximum service with minimum cost of maintenance. I, therefore, believe that all concrete slabs should be reinforced which would include the concrete base for roads finished with a bituminous concrete or asphalt top. The reinforcement will add strength to the base and if cracks should occur it will hold the slab together and prevent the top from being forced into the crack by traffic and thereby cause an uneven surface.

The addition of reinforcement would permit of reducing the thickness of the concrete base by at least an inch and effect a saving in the cost of the road. At present day prices the saving as compared with one inch of concrete would amount to 15 to 25 cents a square yard depending on the weight of the steel 56 pounds per 100 sq. ft. or lighter.



*Placing the Freshly Mixed Concrete on the Reinforcing*

# Discussion of Mr. Kuhn's Paper

## By Harry D. Beaton—National Steel Fabric Co.

In discussing Mr. Kuhn's paper let me amplify briefly the history he has given of the use of reinforcement.

By 1914 the concrete pavement was generally recognized as one of the durable pavements that would withstand heavy traffic. Its use was rapidly increasing. Even before then, however, far-sighted engineers had become aware that no known pavement that could be economically constructed over long periods of time could possibly endure the geometric increase in traffic, both in volume and weight, that was occurring. Something had to be done. Engineering Principles offered the suggestion: Why not steel reinforcement? The Idea was scientifically sound, as Mr. Kuhn has proven, but its general adoption was impeded by the from Missouri mental attitude, by the penny-wise financial policy, by the clamor of conflicting claims of material interests, and by the natural reluctance of road builders to be bothered by new devices. Stronger than all these was the impelling need created by the traffic situation. State after State viewed with alarm the deterioration of its pavements—the loss in invested capital was unpleasantly obvious to the tax-payer. The use of reinforcement spread in growing ratio to the results noted, until now Pennsylvania requires its altogether, New York almost entirely, North Carolina very largely in a comprehensive road building program, and New Jersey and other progressive States to a considerable extent. It has stood the test,—roads built with reinforcement endure, with less maintenance than roads without it. It reduces the ultimate, or real cost of the road.

One other fact about reinforcement has been proved by use; it pays to use heavier material than was at first anticipated. Pennsylvania has even gone up to sixty-five (65) pounds. A comparison of pavements reinforced with weight from thirty-five to sixty pounds built and used under similar conditions shows a better present condition and lower total maintenance cost as the weight of reinforcement has increased. The Engineering News Record of January 12, telling what 1921 developed in Paved Road Design, says: "An increase of the weight of the steel was observable in all states where reinforcing is general."

The ideal condition to be met, that is, on stable soil, would be to have sufficient reinforcement to offset temperature stresses,—for longer slabs, but that is now economically impracticable. We approach it as a constant under variable conditions of soil, climate, traffic and finance. What the engineers want to know is exactly what a given amount of reinforcement will do for a certain thickness of slab under certain conditions.

To the number of reasons that Mr. Kuhn gives for the use of reinforcement, I would add that the use of it prevents blow-ups; and prevents one part of the slab riding above the other at cracks, causing surface uneveness. Surface uneveness gives a jolting ride, and causes damage by impact. I agree from the higher tensile strength of wires and greater superficial area for bond strength, that wires should be allowed a preferential, based on their increased tensile and bond strength.

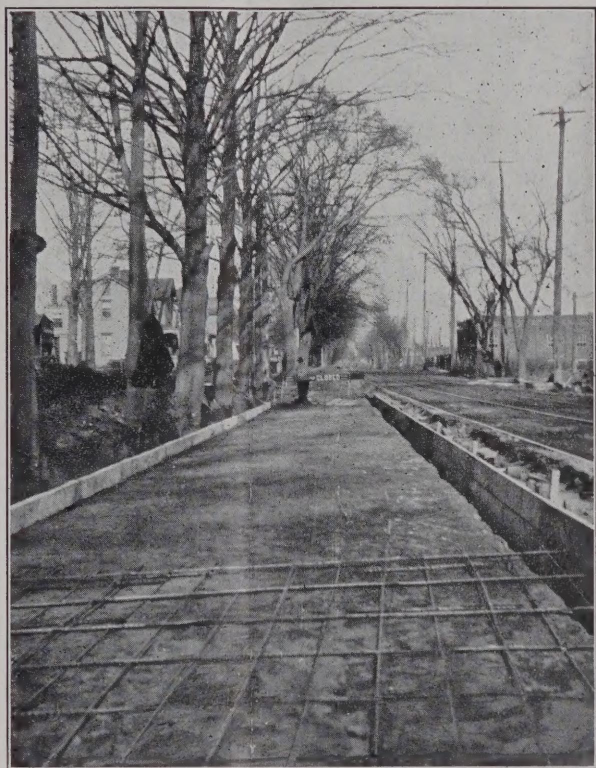
I agree with the 56 pound weight per 100 square feet and where economic conditions justify I might even suggest a slightly heavier material. I believe, too, that all concrete bases should be reinforced. I have noted asphaltic pavements whose surface was spoiled by cracking at the base at regular intervals through contraction and these could have been prevented by reinforcement, which would have obviated the larger cracks.

In specifications I agree with Mr. Kuhn's ratio of about five or six transversely to one longitudinally of the pavement, if the slab is full width. But where the slabs are from nine to twelve feet in width, experience has shown that the lightly reinforced slabs do not crack longitudinally; under these conditions it is our transverse cracks that are troublesome.

I would, therefore, advocate two layers of reinforcement, with the bulk of metal placed longitudinally in order that the length of slab might be increased and to take care of the contraction cracks.

In conclusion, let me emphasize the thought, that experience has fully demonstrated that the weight of steel fabric now being most popularly used—that is approximately 56 pounds per 100 square feet—is the most economical from the standpoint of the original cost of the pavement, as well as the ultimate cost; that is, this amount will give the greatest return for the money expended and this is the ultimate to which we all aim.

Fabricated bar type of reinforcing in place (Dunellen, Route 9)



Showing method of laying concrete road in two sections, with header curb adjacent to trolley tracks.

## General Discussion of Mr. Kuhn's Paper

COL. WHITTEMORE: You all doubtlessly know of the widespread use of wire as reinforcing in glass in large window areas. Some of the large steamship terminals on the Hudson River at Hoboken opposite New York have a great many thousand feet of reinforced glass in windows 12 feet square, and to my knowledge none of those panes of glass have been taken out and replaced since I put them in, in the early part of 1900, and in some cases the glass has cracked into thousands of pieces but the wire still holds them to exclude wind and water. Wire reinforcing in concrete, I take from the speakers' papers, has very largely the function of holding the concrete together due to its tendency to spread by any changes in temperature and since this is an exceedingly important subject, we would be very glad to hear questions on these papers at this time.

MR. SPARKS: I understood Mr. Beaton to say in one case where cracks occurred under an asphalt road with a concrete base that if the base had been reinforced, this would have eased the cracking or the cracking would not have occurred at all.

COL. WHITTEMORE: The crack might have occurred, but it would not have materially spread. It would have been held together by the wire.

MR. BEATON: Right.

MR. SPARKS: Do you know positively that the crack would not have occurred if the wire had been in it?

MR. BEATON: We have found by experience that if there is wire in it the cracks have not occurred. In asphaltic concrete pavements, there are numerous cases where if reinforcement had been used in the base of the pavement in question, it would have prevented certain cracks appearing on the surface. If reinforcement is good for a concrete wearing surface, it certainly can be advantageously used in a base under an asphaltic pavement.

MR. SPARKS: Does it apply especially to wearing surfaces? I believe they have changed the transverse joints from 80 to 40 feet because it was found that the old idea of placing transverse joints still applies.

MR. BEATON: Pennsylvania, in 1921, I think, placed their transverse joints about 100 feet apart up to 200 feet. They were less in some places where the mixer stopped. I do not think they had any more serious cracks in 1921 than when they put the joints 64 feet apart.

MR. BURN: I would like to ask Mr. Kuhn which he considers better, the practice of placing wire fabric on the bottom and pulling it up through the concrete or placing a layer of concrete about 2 inches deep and then laying the fabric on it?

MR. KUHN: By all means strike off the concrete before you finish the leveling and place the reinforcing material. You never know, when pulling up through the concrete, exactly where it is. You do know exactly where it is the other way.

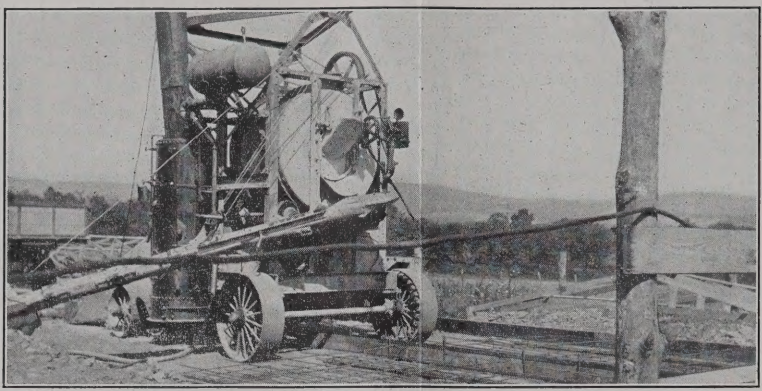
MR. BURN: That was the method used on our Budd Lake job—striking off the concrete.

MR. KUHN: I know of one case where instead of pulling it up through the concrete, the men got tired and laid it on the subgrade and forgot it. In that case it was a pure waste of wire as it did not do any good. First strike off your concrete and then place the reinforcing material.

MR. BURN: From observation I believe that is the common practice and not laying the wire on the bottom and attempting to pull it through.

MR. ALDRICH: Do you know of any experimental results as to placing reinforcement near the top or near the bottom?

MR. KUHN: Personally I do not know of any such tests made. There are many theories about what happens to concrete slabs when they heave, but as the ground beneath your slab is usually of a cool nature, it is natural to assume that the heaving action occurs to your slab more when it freezes and is more or less uniform. That is borne out by trolley rails on ties above the surface of the ground where they leave a space of a quarter of an inch for contraction and expansion and fasten with bolts. If we put the rails beneath a brick or Belgian block pavement we can weld the joints together, which would be an absolutely rigid connection. The rails on State Street of this city are laid in that manner showing that the heat does not penetrate below the slab. After the slab has heaved due to freezing there comes a thaw and the edges of the pavement are apt to sink before the middle. In that case the middle is supported and as the two sides expand the slab cracks. The compressive strength of concrete is high but the tensile strength is low.



*Beginning the Laying of Concrete on the Brick Tavern-Perryville Job (Route 9, Sec. 2)*

MR. ALDRICH: The effect of the frost is realized. The ground thaws down for a few inches and becomes soft. Then you may get a cold night or two or three cold days and the ground which has thawed and become full of water will freeze and expand. In that case you would have your expansion near the edge of the pavement and you would need your steel near the bottom.

MR. KUHN: I differ with you. Two-thirds of this thawed surface becomes soft and sinks half an inch and when this freezes it is not going to affect the edge of the slab.

MR. ALDRICH: I meant to show the different theories. There should be some experimental sections laid with the reinforcing in the top and also in the bottom so as to get practical results.

COL. HOWARD: This question has been gone into for 20 years, as to where the reinforcing is needed, whether it should be 2 in. from the top or 2 in. from the bottom. Engineering practice and better judgment decree that it shall be 2 in. from the top. The old Clinton Wire Cloth Company, originators of wire cloth fabric, found that out in southern California. The Southern Pacific Railroad Company have a number of oil wells. At certain times of the year they would have an excess quantity of oil and had to store that oil somehow. They scraped holes in the ground but lost a considerable amount of oil by seepage with that method. They tried ordinary concrete but that cracked all to pieces and the result was a failure. They tried using mesh both from the top and bottom and found when they used 1½ in. mesh with a 4 in. slab of concrete just below the top of the surface of the concrete these cracks were not found. There were some hair-line cracks on top of the concrete but nothing serious. They only used 20-22 pound mesh. This showed that the better place to put your mesh was on the top below the surface. It also showed the advantage of mesh over bar.

MR. BURN: We had a piece of road constructed near Glen Gardner. We used reinforcement 25 lbs. per 100 square feet 2 in. from the top. Only one crack appeared a short time ago. The mix was 1-2-3 and 6 in. concrete.

MR. BRAGG: In line with the question relative to preventing cracks in the base by Mr. Sparks and the proper weight to use, I will say that at the last convention of the American Association of State Highway officials, the office of the Bureau of Public Roads presented figures to show that in order to absolutely prevent cracking of the concrete in pavements it would be necessary to use 1,230 lbs. per 100 square feet instead of 56. I believe the theory and accepted idea is that this reinforcement can prevent cracks from opening up rather than to prevent these cracks entirely. I would like to ask Mr. Kuhn if he does not feel that in a good many cases, by this method of laying fabric by placing it upon a 2 in. layer of concrete that the bond is destroyed at the line of reinforcement due to the fact that the concrete may lie there until it is pretty thoroughly dried out and more or less disintegrated before the fabric is placed.

MR. KUHN: In my opinion that can only happen possibly through drying out after being spread to grade of the surface area of the first layer of concrete before putting on the reinforcement. If it is put down in sheets, the time of the interval between striking off the concrete and laying the reinforcement is only a couple of minutes and there is no chance for drying out. You waste that much time in shifting the boom or chute on the mixer. If you spread an area of 15 or 20 feet square and then go back and place reinforcement over that area of either fabric or bars, the first portion is going to be somewhat dried up.

MR. BRAGG: I had in mind the delay in getting the material to the mixer. It is necessary to shut down the mixer and sometimes you have a portion of your fabric covered and the other half uncovered. It is good practice to throw that material off the sub-grade but I do not think it is done. What do your specifications call for when you come to the end of a slab?

MR. KUHN: The specifications call for finishing that slab. You call for finishing and putting in an expansion joint rather than taking a chance on getting a proper bond between the concrete going against your slab that was standing for some time. The same thing holds true with a layer of concrete on the ground.

MR. BRAGG: I do not feel that in a good many cases the wearing strength and value of the concrete under a layer of fabric is destroyed.

Under certain atmospheric and ordinary workday conditions, we get a layer too thin to guarantee any sort of satisfactory concrete.

MR. KUHN: You have in mind two layers of reinforcing, one layer 4 in. or 6 in. from the bottom. Then with two layers of reinforcement, it does not take long to spread the concrete and put the fabric on it.

MR. SPEER: I would like to ask if you have had any experience in having the wire leave a void after the finishing machine has gone over the top layer. Whether the finishing machine when going over and tamping, does not have a tendency to drive the wire down which springs back and leaves a void.

MR. KUHN: I could not say. I have had no practical experience in that connection. From my observation I would not imagine that you would get voids. There is a certain amount of spring in your reinforcement, too, which would take care of this. The tamping of the finishing machine would force down the fine as well as the coarse aggregate if a void should happen to occur.

MR. COLLINS: Mr. Chairman, I would like to ask a question. I think the matter of monolithic construction in concrete road paving is a very important one. I have just built a section of road in Cranford which is taken care of by reinforcing. These slabs averaged 43 feet in length and 15 feet in width. Around the edge there is one ⅝ in. bar. Longitudinal bars run right through the joints. The principles of construction are the simplest imaginable. There is no question about monolithic construction being a very good one. The simplicity of the thing commends itself, as there is only one operation. I think the transverse joints are handled the same way. They are belted and the slab rolled and finished with one operation. After finishing there is a certain amount of finishing with a trowel. The best way to bind each slab around with heavy reinforcement. It has been very successful so far. Steel is ⅝ in. square.

*Showing method of dumping the concrete from trucks on the fabricated bar reinforcing (Dunellen, Route 9).*

COL. WHITTEMORE: That reinforcement was bars of iron.

MR. SHERBAUM: I believe there is a corrosive effect on steel after it is placed in the concrete. I would like to inquire whether the wire should be galvanized, and if not, whether there is any particular advantage in galvanized wire outside of the fact that it prevents corrossion before it is put in the pavement.

MR. KUHN: We recommend ungalvanized wire. With the galvanized wire the only real advantage is that a contractor might get a carload of material and let it lay around for six months and in the meantime it becomes badly corroded. A solid coat of rust on the wire does not affect the strength of the wire and materially increases the bond between the concrete and the steel. If it is a coarse scale, then the only bond is with the scale and not with the steel, and then the steel is not functioning. That is about the only real benefit of galvanizing.

# Merits of Bar Reinforcement for Concrete Pavements

## By W. S. Edge, Concrete Steel Co.

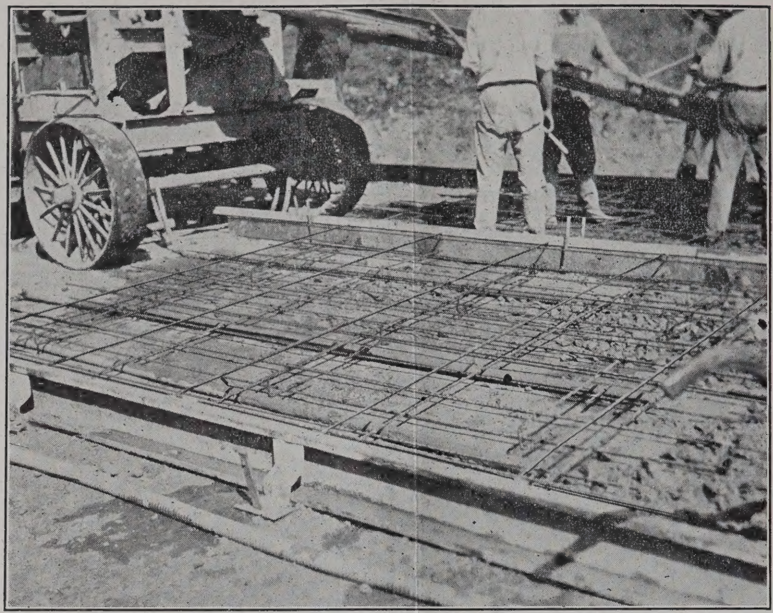
The subject of bar reinforcement for concrete pavements is one that has occupied a good deal of my time for the past three years. My company has been interested in the matter to the extent that they desired to find out whether concrete pavements needed reinforcement and if so what was the best type and the proper amount of steel to use for this purpose. In other words that was my job. Please do not think that I pose as an expert who will tell you the correct solution of this whole matter, but rather as one who is studying the great problem with a view of determining the best way of doing the job in the most economical manner possible.

My interests have been mainly directed heretofore along the lines of reinforced concrete building construction and similar heavy structures of reinforced concrete. In the early days of this industry there was a great deal of both woven and welded mesh used for reinforcement particularly for floor slabs where large areas were employed. We soon found, however, that a deformed bar reinforcement could be substituted with marked economy, particularly where heavy reinforcement was required. It has become almost the universal practice in the building world, therefore, to use deformed bars, and with the advent of more rigid specifications, various types of supporting and tying devices to space and support the steel have come into use. We still use mesh in certain kinds of pipe and sewer work where it has advantages and also for light shrinkage reinforcement in buildings over so-called joist construction. It is also used in New York City in combination with skeleton steel construction and cinder concrete arches where an archaic building code allows this type of reinforcement certain advantages. With our past experience it was perfectly natural that we should expect to find an economy in the use of deformed bars in concrete road construction and such we have found to be usually the case where a reinforcement of 40 lbs. weight per 100 sq. ft. or greater is required. A deformed or plain steel bar is one of the very cheapest forms into which the metal can be rolled and that in a measure, explains its now well nigh universal use in reinforced concrete construction.

In the course of our experience with reinforced concrete buildings and other reinforced concrete structures we have developed numerous special devices which, in certain classes of work have effected marked economies in assembling steel reinforcement. In every case their use has produced a better and more workmanlike job and where there was much repetition of similar arrangement of reinforcing elements remarkable economies have been secured.

This is true of such structures as docks, piers and warehouses and also of pre-cast concrete piles.

We experimented with various methods of introducing



*"Close-up" Showing Forms for Side of Pavement and Center Joint, also Bar Reinforcing in Place (West Portal, Route 9, Sec. 1)*

steel bars into a road and soon reached the conclusion that no method of placing loose bars could be anything but a nuisance and a delay to the construction. The road contractors were particularly outspoken against any form of loose bar reinforcement; in fact the mere mention of it was sufficient to start something. We, therefore, have standardized on the assembly of bar reinforcement into units or mats, the size of which depends upon the manner in which the construction is to be handled. Ordinarily they are made either the full or half width of the road and from 8 to 14 ft. long. The matter of length being decided by the type of equipment employed by the contractor; for example, if he is using a boom and bucket a length as great as 14 ft. may be adopted and if he is using a chute he may not wish to pour more than eight feet at a time.

The first road work with which we had anything to do where bar reinforcement was employed was at East Brookfield, Mass., on a State Road job on which Bianchi and Co. were contractors. Many of the details of this work were worked out by the State Engineers of the Massachusetts State Highway Department and the engineer of the contractors. We sold the steel, but otherwise were more observers than directors of this operation.

The reinforcement consisted of quite heavy bars ½ inch square, spaced about 2 feet apart transversely and concentrated longitudinally near the edge and centre of the road. These mats were 9 ft. 8 in. x 14 ft. 0 in., one-half of the 20 ft. road being built at a time. For a mat of this type it is possible to build the assembly frame waist high since all the tys can be made from the outside. The fabrication was a comparatively simple operation. The bars in bundles were distributed along the right of way so that a pre-determined number of units could be made up at any given point. The assembly frame was very light and was easily carried by two men from one point to the next. The bundles of bars were cut open and the bars placed in the frame, only three lengths of bars being used on this work. Then they were tied at all intersections and the assembled units were piled along side the road. Two men easily kept ahead of the work and did not have to work steadily either and the contractor averaged about 410 lineal ft. of 10 ft. width of road a day.

The specifications called for bottom reinforcement and the mat of bars was placed directly upon three pipe supports which were pulled out as the concrete came in.

The contractor was well pleased with the progress made on this work and informed me that the use of the reinforcing steel did not retard his progress noticeably. Dowels were used on this work across the longitudinal centre joint. The road being constructed half at a time, these dowels were bent at right angles when placed in the first section and were later straightened, but not at the exact point of bend. The idea being to provide a certain amount of flexibility at this joint.

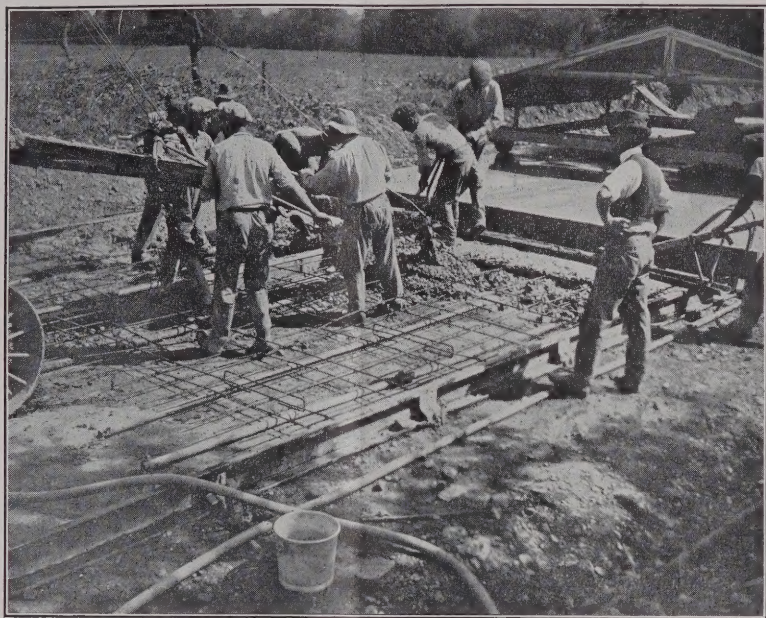
Many other constructions of this general type were carried out in Massachusetts, Rhode Island, Delaware, New York, and New Jersey.

In New Jersey through the courtesy of the Highway Department, two roads were built in which a top and bottom reinforcement composed of deformed bars was substituted for two layers of mesh which was originally specified. It seemed to me that here was a case where a large economy was bound to result to the contractor in the simplified construction. With the use of fabric he would have to level off about two inches of concrete and then place the bottom reinforcement, then run more concrete striking off within two inches of the top, then place his upper layer and finally finish the section. With bar reinforcement his construction operations are reduced to placing the unit or cage of steel and concreting his entire section at once. The design of this reinforcement was made in our office in about five minutes and is far from ideal and we think we have been able to improve on it in several respects, but it served its purpose and so far as I know was satisfactory to all concerned. The cost of making the mats up in the field and tieing them, altogether proved to be not over one cent a sq. yd. of single mat or two cents a sq. yd. of road.

The methods used on Route 9, Sec. 1 & 2, known as the West Portal job are similar to those used on earlier jobs with the exception that the necessity of tieing the centre of the mats made a 14 in. frame from the ground necessary. The addition of structural angles on the top of the frame also made assembly easier and more rapid. Two men fabricating easily kept ahead of the work and I understand took a sub-contract at one cent per sq. yd. of mat for fabrication. I have heard many favorable comments on this work, but I have also heard some criticism of minor details. Personally I do not like the method of supporting from the subgrade nor do I consider the reinforcement sufficiently rigid in itself so that our efforts have been directed toward making improvements in the reinforcement without increasing the cost.

We have always taken the attitude that it was not our function to design the road reinforcement, but that when the highway engineer told us what he wanted then we would be glad to make suggestions as to the best method of carrying out his wishes in a practical way, always with a view to providing an economical construction.

During the past year I have spent a great deal of time



*Putting the Concrete in Place; note the even spacing of the Reinforcing Bars (West Portal Job) Route 9*

with Highway Engineers from North Carolina to Maine and as far west as Illinois, and as a result of my very pleasant friendship and discussions it seems to me that the researches of Mr. A. T. Goldbeck at Washington, D. C., and of Mr. Clifford Older at Springfield, Ill., stand out above the other investigation work that has been done and form really a large advance toward the solution of this question.

Without going into great detail with regard to these experiments which would form sufficient material for a volume, perhaps the following points are worth attention.

A concrete slab plain or reinforced works due to temperature changes, lifting in the centre in the middle of a warm day and lifting at the edges at night. This action is especially marked with an 18 or 20 foot slab and will cause its failure by a longitudinal crack near the centre, our friends from Pennsylvania to the contrary notwithstanding.

The weakest portion of the slab seems to be the corners at transverse joints and at the centre. Unless the subgrade is bad, the stresses in the under side of the slab do not seem to be serious in a 20 ft. road where a center longitudinal joint is used.

The dowelling of the slabs together longitudinally and stiffening the edges of the slabs is highly important and transverse reinforcement in the top of the slab is absolutely necessary.

To meet these conditions as we believe them to exist we have developed a design which was shown for the first time at the Chicago Good Roads Show. This caused so much interest that we are encouraged to recommend it for all concrete roads where conditions justify its use.

This unit is designed to rest directly on the sub-grade being supported along the edges on the ends of the hooked transverse rods and at the 1-3 points by the truss support bars. It can be collapsed flat for piling and transporting if desired.

The cost of fabrication is only slightly greater than that of a plain mat of the same size and the same number of ties. It can be made either upside down or right side up in the assembling frame. One would naturally think that there would be a tendency for this unit to collapse in use, but such has not proved to be the case; as a matter of fact the first unit of this type that we built successfully resisted the efforts of 4 men to collapse it. Certain changes in the tying where necessary to produce the desired result. The combination of deformed bars and spring wire bar ties gives exactly the action we desire, i. e. a yielding yet powerful spring grip which will allow the bar to be rotated but will not allow either bar to slip under normal usage.

Considering the details of design, our main reinforcement is transverse near the top of the slab with a concentration of longitudinal steel near the edges and centre of the road where it is most needed.

The truss bars are not counted as full reinforcement because parts of them which touch the ground will undoubtedly rust out in the course of time. So far we have found no other method of support which is equally satisfactory that does not cost more than this and besides, anything in the nature of chairs or auxiliary supports would be a nuisance and just one thing more the contractor would have to bother with.

The cost of this type to the contractor will be about the same or less than mesh or fabric at present prices from 56 lb. per 100 sq. ft. and up. There are certain factors that must be borne in mind, however. We use preferably ⅜ in. round bars, although in the heavier weights ½ in. round or square bars may be employed.

The spacing of the bars should be wide enough so that a man can step freely through it.

I believe that this self-supporting feature should commend itself to engineers and contractors alike, especially when you consider that it can be secured at only a slight increase in cost over plain bar reinforcement and at no increase at all over fabric as now employed.

We have also developed several types of double reinforcement which are an improvement over that used last summer, in our opinion.

# Discussion of Mr. Edge's Paper

## By Mr. C. A Burn, Northern Division Engineer

Mr. Burn: I have listened with considerable interest to Mr. Edge's paper, especialy the part concerning bar reinforcement.

The State Labor Division used bar reinforcement in some work at Dunellen, N. J., on our Route No. 9. This work consisted of constructing approximately one mile of one course reinforced concrete pavement, 1-2-4 mix, eight (8 in.) thick, and was laid in two sections, one on either side of the trolley tracks. Each section was 12 feet wide, with an 8 inch header curb on the side adjoining the trolley tracks, cast integral with the pavement.

The reinforcement was of the double line type, made up of two mats of 3/8 in. deformed bar, 11 ft. x 12 ft. The main members in each mat ran longitudinal with the pavement, and were spaced 9 in. center to center on the bottom mat, and 18 in. center to center on the top mat. Transverse members in each mat were spaced 28 in. center to center. The mats were separated by six spacers which were made up of 3/8 in. bars bent in a rectangular shape, about 3 ft. 6 in. long and 3 3/8 in. wide. Intersections were tied with No. 2 Havemeyer Bar Ties.

The main difficulty we encountered in handling this reinforcement was in getting it placed in the proper position in the pavement. First, we tried using about 12 common bricks, broken in half, and placed on the sub-grade, in order to keep the mats the required 2 in. from the bottom of the sub-grade, but this did not prove entirely satisfactory. Later, we used four 2 in. pipe.

The difficulty we found in using pipe was when we attempted to pull it from under the wet concrete, since we had to handle it by man power, as the concrete was mixed at a central plant and hauled directly to the work in one ton Ford trucks, equipped with Lee Dump Bodies.

We improvised a temporary platform, one end of which was rested on the trolley rail, and the other end on legs set in the sub-grade, and the trucks were backed on to this small platform and the concrete dumped directly upon the mats. The dumping of this heavy mass of concrete caused the mats to settle in the center, and spring up on the sides. In order to overcome this, great care was taken in dumping the first load, and spreading same properly, working the concrete under the mat all the while. After spreading the first load carefully, it was an easy matter to spread the remaining three loads, the amount required to complete the section.

If some method can be devised to place the mats properly on the subgrade, and then retain them in position while the concrete is being deposited, I believe that bar reinforcement will work out much better than fabric reinforcement.

Mr. Edge, in his paper, mentions that it costs about 2 cents per square yard to assemble the mats. Our work was in the center of the City of Dunellen, and we were unable to assemble the mats along the road, where required, but had to take advantage of available vacant lots to do this work, and carry them from such vantage points to the job. This required four additional men, and brought our cost up to 5 cents per square yard. I believe where a highway is being constructed in the country districts, and the mats may be assembled alongside the road, the cost could be cut considerably, possibly to 2 cents per square yard, as stated by Mr. Edge.

We also found that it was desirable to tie the ends of the bars of the adjoining mats together with bar ties. This seemed to help support the mat and keep it in place when the concrete was being deposited and spread.

At the present time, I cannot think of anything else to add, except that I believe the trussed bar, which Mr. Edge has shown, may help to place the reinforcement where it belongs.

Col. Whittemore: Are there any questions on this very important subject?

Mr. Keasby: I would like to inquire the approximate cost per square yard, which bar reinforcement adds to the cost of the pavement.

Mr. Edge: The approximate cost depends upon just what you will require. Ordinarily the cost would be the same or less than for mesh reinforcement, depending upon the type.

## Contract News

Prepared to August 7, 1922

Feb. 6—Route 6, Section 5, Shirley-Oldman's Creek, Reinforced Concrete Paving job, 6.812 miles, 20 feet wide with gravel shoulders, was awarded to the Benjamin Foster Company, Philadelphia, Pennsylvania, on their low bid of $254,021.53.

Feb. 15—Route 6, Section 6—Old Man's Creek-Mullica Hill, Reinforced Concrete Paving job, 5.028 miles, 20-30 feet wide with gravel shoulders, was awarded to the firm of M. Staub, Swedesboro, New Jersey, on his low bid of $203,660.48.

Feb. 14—Route 2, Section 3, South Broad St., Storm Drain job was awarded to A. G. Thompson, of Trenton, New Jersey, on his low bid of $17,665.06.

March 6—Route 6, Section 10, Quinton to Marlboro, Grading and Graveling job, 5.994 miles, 20 feet wide, with earth shoulders, was awarded to the Masterson Construction Corporation, New York City, on their low bid of $79,793.17.

March 6—Route 6, Section 11, Salem to Quinton, Reinforced Concrete paving job, 2.648 miles, 20 feet wide with gravel shoulders was awarded to Joseph E. Burke, of Plainfield, New Jersey, on his low bid of $111,833.79.

Feb. 27—Route 10, Section 1-B, Arcadian Way to Anderson Ave. in Fort Lee, Reinforced concrete paving job, 0.48 miles, 20 and 30 feet wide with earth shoulders, was awarded to the firm of John J. McGarry, Edgewater, New Jersey, on his low bid of $104,362.61.

Feb. 21—Route 14, Section 5, Cape May Court House to Swainton, Reinforced Concrete paving job, 2.987 miles, 20 feet wide with gravel shoulders, was awarded to the firm of Sutton and Corson, Ocean City, New Jersey, on their low bid of $118,776.16.

March 8—Route 4, Section 9, Smithville-Mullica River, Warrenite Bitulithic job, on concrete base, 3.748 miles, thirty feet wide, with gravel shoulders was awarded to C. H. Earle of Hackensack, New Jersey, on his low bid of $374,533.77.

March 8—Route 4, Section 6, Eatontown-West Long Branch, Sheet Asphalt job on Concrete Base, 2.69 miles, 20 feet wide with earth shoulders was awarded to the Utility Construction Company of New Brunswick, New Jersey, on their low bid of $149,679.74.

April 14—Route 5, Section 5, Madison Ave., Madison Township and Borough of Madison, Warrenite Bitulithic on Concrete base, 2.032 miles, 20 feet wide with earth shoulders, was awarded to the Northern Construction Company, of Newark, New Jersey, on their low bid of $117,-844.37.

April 13—Route 15, Sections 2 and 3, Bridgeton-Millville, Warrenite Bitulithic on Concrete base, 8 miles, 20 feet wide with gravel shoulders was awarded to the Tri-State Construction Company of Bridgeton, New Jersey, on their low bid of $455,500.12.

April 14—Route 4, Section 14, Laurelton-Lakewood, 3.875 miles, Reinforced Concrete Paving job, 20 feet wide with gravel shoulders was awarded to C. H. Earle of Hackensack, New Jersey, on his low bid of $144,705.68.

April 28—Route 4, Section 13, Richmond Ave., Point Pleasant Beach, Reinforced Concrete paving job, 0.848 miles, 20 feet wide with earth shoulders was awarded to C. H. Earle of Hackensack, New Jersey, on his low bid of $35,471.76.

May 16—Route 4, Section 15, Lakewood (County section) 2.556 miles Reinforced Concrete Paving job, twenty-eight and thirty feet wide, was awarded to the Public Service Production Company of Newark, on their low bid of $75,748.82.

May 16—Route 4, Section 15, Lakewood (Township Section) 2.556 miles, Reinforced concrete paving job, 36 and 50 feet wide was awarded to C. H. Earle of Hackensack, New Jersey, on his low bid of $105,741.10.

May 23—Route 6, Section 12, East Commerce Street, Bridgeton, 1.314 miles long. Sheet Asphalt paving job on Concrete Base, 20 and 32 feet wide, was awarded to E. K. Mixner Co., on their low bid of $80,422.01.

May 26—Route 9, Section 8, North Branch-Somerville, 3.837 miles, Reinforced Concrete paving job, 20 feet wide with earth shoulder was awarded to Ralph Sangiovanni, on his low bid of $159,077.59.

May 26—Route 16, Section 3, Bedminister-Pluckamin, 2.415 miles Reinforced Concrete paving job, 20 feet wide with earth shoulders was awarded to Ralph Sangiovanni, on his low bid of $135,648.39.

May 26—Route 4, Section 16, Maine St., Toms River, 1.096 miles long, Reinforced Concrete paving job, 20, 30, 36, 38 and 56 feet wide with gravel shoulders was awarded to the Public Service Production Company of Newark, on their low bid of $62,864.59.

June 2—Route 5, Section 9, Barkers Corner-Hackettstown, 2.99 miles Reinforced Concrete paving job, 20 and 48 feet wide with earth shoulders was awarded to Frank J. Groman, of Bethlehem, Pennsylvania, on his low bid of $230,274.37.

June 6—Route 2, Section 3-A, Whitehorse-Crosswicks Creek, 0.389 miles, Reinforced Concrete paving job, 30 and 40 feet wide was awarded to Daniel Klockner, of Trenton, New Jersey, on his low bid of $37,472.82.

Jan. 10—Route 6, Section 8, Pearl St., Bridgeton, Reinforced Concrete paving job, 0.455 miles, 20 and 30 feet wide with gravel shoulders was awarded to the Tri-State Construction Company, Bridgeton, New Jersey, on their low bid of $76,302.36.

April 5—Route 4, Section 10, Shadow Lawn-Roseld Avenue, Sheet Asphalt Paving job on Concrete Base, 2.41 miles, 20 and 36 feet wide with earth shoulders, was awarded to Newark Paving Company, of Newark, New Jersey, on their low bid of $104,969.51.

April 4—Route 2, Section 3, South Broad Street, Sheet Asphalt job, on Concrete Base, 0.648 miles, 48.5 feet wide, was awarded to J. J. Barrett, Trenton, New Jersey, on his low bid of $69,433.77.

March 1—Route 11, Section 1, Main Street, Passaic, Sheet Asphalt job, on Concrete Base, 0.257 miles, 22 feet, 2 inches wide, was awarded to Union Building Construction Company, Passaic, New Jersey, on their low bid of $15,160.15.

April 5—Route 4, Section 12, Sea Girt Avenue, Reinforced Concrete Paving job, 0.162 miles, 20 feet wide with earth shoulders was awarded to T. H. Riddle, New Brunswick, New Jersey, on his low bid of $8,569.23.

April 4—Route 9, Section 6, Somerville-Bound Brook, Reinforced Concrete Paving job, 2.491 miles, 20 feet wide, earth shoulders was awarded to Salmon Brothers, Netcong, New Jersey, on their low bid of $131,710.10.

March 31—Route 4, Section 5-A, Storm Drain in Red Bank, was awarded to Chas. J. Romano, Montclair, New Jersey, on his low bid of $15,314.85.

April 10—Route 6, Section 9, Salem-Collier's Run, Reinforced Concrete Paving job, 4.752 miles, 20 feet wide with gravel shoulders was awarded to Sampson & Reuter, Elizabeth, New Jersey, on their low bid of $196,975.08.

April 18—Route 9, Section 5, Union Avenue, Bound Brook, Sheet Asphalt on Concrete Base, 1.501 miles, 20 feet wide with earth shoulders was awarded to the Utility Construction Company of New Brunswick, New Jersey, on their low bid of $93,090.31.

April 10—Route 3, Section 8, Camden-Clements Bridge Road, Reinforced Concrete Paving job, 3.82 miles, 36 and 40 feet with earth shoulders was awarded to W. Penn Corson, Camden, N. J., on his low bid of $269,644.85.

April 10, Route 3, Section 9, Clements Bridge Road-Kirkwood, Reinforced Concrete Paving job, 3.756 miles, 29 feet wide with earth shoulders was awarded to John M. Kelley Construction Co., Camden, N. J., on their low bid of $200,592.95.

April 10—Route 3, Section 10, Kirkwood-Berlin, Reinforced Concrete Paving job, 5.576 miles, 29 feet wide with earth shoulders was awarded to John M. Kelley Construction Co., Camden, N. J., on their low bid of $297,993.89.

May 29—Route 9, Section B, West Front Street, Plain-

field, Sheet Asphalt paving job on Concrete Base, 1.929 miles, 40 and 41 feet wide, was awarded to the Union Paving Company, of Newark, New Jersey, on their low bid of $219,316.20.

June 20—Route 1, Section 6, Trenton City Line-Nottingham Way, reinforced concrete paving job, 0.928 miles, 39 feet, six inches wide, was awarded to Rees and Taylor, of Trenton, New Jersey, on their low bid of $95,347.47.

June 21—Route 4, Section 5-A, Maple Avenue, Red Bank, Sheet Asphalt paving job on Concrete Base, 1.308 miles, 40, 33 and 22 feet wide with earth shoulder was awarded to J. J. Barrett, of Trenton, New Jersey, on his low bid of $93,429.13.

June 21—Route 4, Section 11, Main Street, Avon, New Jersey, Warrenite Bitulithic surface on Concrete Base, 0.663 miles, 43 feet wide with earth shoulders was awarded to the East Jersey Bridge Company, of Perth Amboy, New Jersey, on their low bid of $54,814.34.

June 21—Route 5, Section 6, Speedwell Avenue, Morristown, Warrenite Bitulithic surface on Concrete Base, 1.426 miles, 23 feet, 3½ inches wide was awarded to J. S. Geiger Sons of Newark, New Jersey, on their low bid of $144,-892.74.

June 21—Route 9, Section 9, Phillipsburg-Still Valley, Reinforced Concrete paving job, 1.68 miles, 20 and 36 feet wide with earth shoulders was awarded to Crilly and Cannon of Phillipsburg, New Jersey, on their low bid of $110,345.40.

July 7—Route 4, Section 17, Barnegat, Reinforced Concrete job, 1.0 miles, 20 feet wide with gravel shoulders, was awarded to the Public Service Production Company of Newark, New Jersey, on their low bid of $43,931.94.

July 7—Route 4, Section 18, Tuckerton, Reinforced Concrete job, 1.5 miles, 20 feet wide with gravel shoulders, was awarded to the Public Service Production Company of Newark, New Jersey, on their low bid of $59,913.83.

July 13—Route 9, Section 7, Main Street, Somerville, Reinforced Concrete job, 0.497 miles, was awarded to J. L. Bachman of Linden, N. J., on his low bid of $74,180.25.

July 14—Route 16, Section 2, Mine Mount Road-Bedminster Corner, Reinforced Concrete job, 2.515 miles, was awarded to the Engineering Construction Corporation, Philadelphia, Pennsylvania, on their low bid of $166,-802.65.

July 14—Route 1, Section 13, Highland Park-Stelton Road, Warrenite Bitulithic on Concrete Base, was awarded to S. S. Thompson & Company, Incorporated, Red Bank, New Jersey, on their low bid of $305,394.61.

July 14—Route 1, Section 14, Stelton Road-Metuchen, Warrenite Bitulithic on a Concrete Base, was awarded to S. S. Thompson & Company, Incorporated, Red Bank, New Jersey, on their low bid of $344,784.65.

July 14—Route 9, Section 9A, Still Valley-Bloomsbury, Reinforced Concrete job, 2.92 miles, was awarded to Bernard E. Tighe Construction Company of Easton, Pennsylvania, on their low bid of $127,785.84.

July 21—Route 5, Section 8, Great Meadows-Barker's Corner, Reinforced Concrete, was awarded to Salmon Bros., Netcong, New Jersey, on their low bid of $186,-688.69.

**For You—**
**"The Highwayman"**

Do you use roads? Do you want to know where they are being built, and what detours to take, each month.

Then send, TODAY, to

*The Highwayman*
*New Jersey State Highway Department*
*Trenton, N. J.*

Just ask to be put on he Highwayman's list. A postal will do.

# MONTHLY BULLETIN OF DETOURS

Adopted by the New Jersey State Highway Commission

Corrected to August 10, 1922

*All detours posted with signs and blazed with "Arrows"*

Note:—The traveler will find poles banded along each route of the State Highway System to correspond to the colors indicating the direction of the routes.

**Blue** on the posts or signs indicates that the road is running **North** and **South.**
**Red** shows that it lies **East** and **West.**
While **Yellow** tells you that it takes a diagonal course **Northwest** and **Southeast.**
**Brown** indicates that it takes a Diagonal course **Northeast** and **Southwest.**

**ROUTE NO. 1—Lincoln Highway between Newark and Jersey City.**
Closed indefinitely on account of bridge construction. Detour: to reach a point beyond the Passaic River in the vicinity of Newark, or to go to Jersey City from Newark, cross either the Jackson Street Bridge, the Bridge St. Bridge or the Clay St. Bridge, and travel easterly as far as Fourth St., Harrison, thence North on Fourth St. to Hamilton St., going easterly over Hamilton St. to Schuyler Ave., thence westerly over Schuyler Ave. to the Newark Turnpike which parallels the Lincoln Highway to Jersey City. This detour is necessary in Harrison due to the fact that Harrison Avenue, between Fourth Street and Schuyler Ave., an extension of the Newark Turnpike, is being repaired.

**ROUTE NO. 1—Westfield Avenue, City of Elizabeth.**
Under construction. Traffic will detour as follows:

EAST BOUND, follow Cherry Street to Orchard Street, to Prince Street, to North Broad Street.

WEST BOUND, on Prince Street from Broad Street to Orchard Street, to Cherry Street, to Route No. 1.

**ROUTE NO. 1, Section 6—Greenwood Avenue near the City of Trenton**
Under construction. Traffic will detour beginning near the City Line of Trenton at the intersection of Greenwood and Olden Avenues, thence northerly over Olden Avenue to East State Street thence easterly on East State Street to Nottingham Way, thence southeasterly on Nottingham Way to Greenwood Avenue and Bromley Inn.

**ROUTE NO. 2, Section 3—South Broad Street, Trenton.**
Under construction. No detour necessary. Traffic will go through construction.

**ROUTE NO. 2, Section 3-A—Under construction between White Horse and Crosswicks.**
No detour necessary. Traffic will go through construction.

**ROUTE NO. 3, Sections 8, 9 and 10—Under construction between Camden and Berlin.**
Traffic to the Shore from Market Street Ferry, Camden, will go out Federal Street to Haddon Avenue to Mt. Ephraim Avenue, thence over Mt. Ephraim Avenue through Mt. Ephraim, Chews Landing, Blackwood and Clementon to Berlin.
Traffic from the Shore will leave the White Horse Pike at Berlin going through Gibbsboro, Haddonfield, Ellisburg and over the Marlton Pike to Federal Street, Camden, thence over Federal Street to the Market Street Ferry.

**ROUTE NO. 4, Section 5-A—Maple Avenue, Red Bank.**
Under construction. Detour beginning at Maple Avenue and Front Street, thence over Front Street to Broad Street to Bergen Place and Route No. 4.

**ROUTE NO. 4—Sections 6 and 10, under construction between Eatontown-Long Branch Road and Allenhurst.**
Detour beginning on Route No. 4 known as Norwood Ave. in Deal Beach at Darlington Road; westerly on Darlington Road and northerly on Richmond Ave. to Roseld Ave., continuing westerly on Roseld Ave. to the Monmouth Road, or Locust Ave., thence northerly on Monmouth Road or Locust Ave. to Route No. 4 at the junction of Monmouth Road and Cedar Ave., West Long Branch; continue north on Monmouth Road or Route No. 4 to Wall Street, westerly over Wall St. by way of Locust Grove and South Eatontown to South Street, thence northerly by way of South Street to Route No. 4 at Broadway, Eatontown.

**ROUTE NO. 4, Section 11, Avon-by-the-sea, under construction.**
No detour necessary. Traffic will go through construction.

**ROUTE NO. 4, Section 13—Point Pleasant Beach, under construction.**
Detour beginning on Route No. 4 at the intersection of Richmond Avenue and River Avenue just south of the Manasquan River Bridge, thence southerly over River Avenue to Arnold Avenue, thence westerly and southerly over Arnold Avenue to Pine Bluff Avenue, thence westerly over Pine Bluff Avenue to Osborne Avenue, thence southerly on Osborne Avenue to Route No. 4 in West Point Pleasant.
Detour on account of construction of bridge at Inland Waterway, West Point Pleasant, for local traffic, beginning at the intersection of Route No. 4 and Arnold Avenue, West Point Pleasant, and running thence northerly on Arnold Avenue to Pine Bluff Avenue, thence westerly over Pine Bluff Avenue to Osborne Avenue, thence southerly over Osborne Avenue to Route No. 4 in West Point Pleasant.

**ROUTE NO. 4, Section 14—Under construction between Laurelton and Lakewood.**
Detour beginning at intersection of Route No. 4 and Cedar Bridge Road at Laurelton or Burrsville, thence southerly through Cedar Bridge and Silverton to Hooper Avenue, Toms River, thence westerly over Hooper Avenue to Washington Street. thence westerly over Washington Street to Robbins Street, thence southerly over Robbin's Street to Water Street, thence westerly over Water Street to Route No. 4, Toms River.

**ROUTE NO. 4, Section 15—Lakewood, under construction.**
Detour beginning at Route No. 4 on River Avenue and Central Avenue, thence westerly over Central Avenue and the Lakewood-New Egypt Road to Cross Street, thence southeasterly over Cross Street to the Lakewood-Toms River Road or Route No. 4.

Over

**ROUTE NO. 4, Section 16—Toms River, under construction.**
Detour begins at Route No. 4, running northeast on Freehold Road to Walnut Street, east on Walnut Street to Hooper Avenue, south on Hooper Ave., to Water Street, west on Water Street to Route No. 4, Toms River.

**ROUTE NO. 4, Section 17—Barnegat, under construction.**
No detour necessary. Traffic will go through construction.

**ROUTE NO. 4, Section 18—Tuckerton, under construction.**
No detour necessary. Traffic will go through construction.

**ROUTE NO. 5, Section 5—Convent Station to Madison.**
Detour beginning at the corner of South Street and Madison Avenue, Morristown, and running from thence on South Street in a southerly direction to the Morristown-Green Village Road; from thence still southerly on the Morristown-Green Village Road to Loantaka Way; thence easterly on Loantaka Way to Woodlawn Road; thence still easterly on Woodlawn Road to the Madison-Green Village Road; thence northeasterly on the Madison-Green Village Road to Kings Road; thence southeasterly on Kings Road to Waverly Place; thence easterly on Waverly Place to Route No. 5 in Madison.

**ROUTE NO. 5, Section 9—Under construction between Barker's Corner to Hackettstown.**
Detour beginning on Route No. 5 known as Mill Street, Hackettstown, at the intersection with Water Street, thence over Water Street to Mountain Avenue, thence northerly on Mountain Avenue to Little Street, thence westerly on Little Street to Washington Street, thence northerly on Washington Street to Moore Street, thence easterly on Moore Street to Main Street and Route No. 5.

**ROUTE NO. 6, Section 14, Broad Street, Woodbury.**
Under construction from railroad crossing at north end of town to Red Bank Avenue. Detour north end from Westville on Westville-Glassboro Road to Cooper Street to Broad Street, Woodbury.

**ROUTE NO. 6—Mantua Avenue, Woodbury.**
Under construction from Broad Street south to present improvement. Detour at Broad Street and Barber Avenue, thence on Barber Avenue to Woodbury-Glassboro Road to Woodbury Heights, thence to Mantua and Route No. 6.

**ROUTE NO. 6, Sections 5 and 6—Under construction between Mullica Hill and Shirley.**
Detour via Woodstown, Alloway and Aldine to Bridgeton.

**ROUTE NO. 6, Section 9—Under construction between a point south of Woodstown (Lawnside Cemetery) and Salem.**
Detour beginning at a point south of Woodstown (Lawnside Cemetery) through Sharptown to Pointers to Salem. Traffic will be maintained over a portion of the highway under construction from a point 1½ miles north of Salem to Salem.

**ROUTE NO. 6, Sections 10 and 11—Under construction between Salem, Quinton and Bridgeton.**
Detour from Salem through Hagerville, Hancock's Bridge, Harmersville, Canton, Gum Tree Corner and Roadstown to Bridgeton.
For local traffic to Quinton and Alloway detour is arranged from Keasbey St., Salem, north to Grant Street, easterly on Grant Street to Quakerneck Road, continuing on Quakerneck Road, east to Sandy Ridge Road, south to completed section of Route No. 6, thence to Quinton. For Alloway traffic continues easterly on Quakerneck Road.

**ROUTE NO. 9, Section B—Plainfield, under construction.**
Detour beginning at Route No. 9 or Plainfield Avenue and go over Muhlenberg Place to West Second Street, thence over West Second Street to Clinton Avenue, thence over Clinton Avenue to West Front Street or Route No. 9. Traffic will be maintained on West Front Street from Clinton Avenue to the Borough of Dunellen one-half the width at a time.

**ROUTE NO. 9, Sections 5 and 6—Under construction in the Borough of Bound Brook and between Bound Brook and Somerville.**
Detour beginning on Route No. 9 at the concrete arch bridge approaching Raritan Avenue near the easterly Borough Line of Bound Brook, thence southwesterly over the concrete arch bridge by way of Raritan Avenue and westerly over Main Street, Bound Brook, to Shunpike Avenue; thence following Shunpike and Talmadge Avenues through Bound Brook, and westerly over the New Brunswick Turnpike and East Main Street to Somervville to Route No. 9 at Gaston Avenue.

**ROUTE NO. 9, Section 8—Under construction between Somerville and North Branch.**
No detour necessary. Traffic will go through construction.

**ROUTE NO. 9, Sections 1 and 2—Under construction between Perryville and West Portal.**
Detour via Clinton, Glen Gardner, Hampton, Asbury, West Portal.

**ROUTE NO. 9, Sections 9 and 9-A—Under construction between Bloomsbury and Phillipsburg.**
Detour in Bloomsbury via Stewartsville and Straw Church to Phillipsburg. (Detour may be in effect as soon as this information is in the hands of the traveling public.)

**ROUTE NO. 10, Section 1-B—Under construction between Arcadian Way and Anderson Avenue.**
Detour over Bluff Road to Anderson Avenue.

**ROUTE NO. 11 Section 1—Main Street, Passaic, under construction.**
Short detour over local streets.

**Market Street, Paterson, under construction (Connecting Routes No. 10 and No. 12).**
Detour over local streets.

**ROUTE NO. 12, Section 2—Under construction between Parsippany and Denville.**
Detour at Cobb's Corner, Littleton, Morris Plains and Tabor to Denville.

**ROUTE NO. 15, Sections 2 and 3—Under construction between Bridgeton and Millville.**
Detour beginning at the corner of Commerce and Walnut Streets, Bridgeton, thence northerly over Walnut Street to Irving Avenue, thence easterly over Irving Avenue and Beaver Dam Road through Carmel to the intersection of Route No. 15 and the Beaver Dam Road near Millville.

**ROUTE NO. 15, Section 4—At Millville under constr uction from Section No. 3 to center of Millville.**
Detour from Beaver Dam Road northeast over gravel road to Cooper Stret, east on Cooper Street to Sharp Street, northeast on Sharp Street to Columbia Avenue, thence southeast on Columbia Ave., to North High Street, southerly on North High Street to Route No. 15, center of Millville.
Traffic for Vineland continue northeast on Sharp Street to Malaga Road to Vineland.

**ROUTE NO. 16, Section 3—Under construction between Bedminster Corner and Pluckemin.**
No detour necessary. Traffic will go through construction.